Tangential Filtration Housing

Cross Reference to Related Applications

The present application claims priority to United States provisional patent application number 60/425,198 filed November 8, 2002. The entire disclosure of which is incorporated herein by reference.

Field of the Invention

The present invention relates generally to filtration apparatus and, more particularly, to a housing apparatus for accommodating an exchangeable filtration cassette.

Background of the Invention

Microfiltration and ultrafiltration equipment is required for many applications including the concentration; fractionation and ultrapurification of protein solutions; the depyrogenation of water and intravenous solutions; the desalting of biologicals; and the removal of macromolecules and colloids. A well-known type of such apparatus employs a filtration cassette comprising a stacked array of ultrafiltration membranes separated by flow accommodating screens and retained between demountable plates. Some of the problems associated with such equipment stem from the requirements for frequent cleaning and replacement of filtration cassettes. One ultrafiltration unit, for example, utilizes fluid flow parts in each of the demountable plates thereby necessitating dismantling of an entire system for each cleaning or filtration filtration cassette replacement procedure. Other ultrafiltration units require specially designed

filtration cassettes and are not compatible for use with commonly available filtration cassettes. One such unit is disclosed in U.S. Patent Number 4,430,218. Another unit is disclosed in U.S. Patent Number 4,715,955, which includes a housing having internal flow passages. The flow passages, however, are oriented to be perpendicular or parallel to the transverse edges of the housing which thereby provides horizontally-oriented surfaces on which leftover filtrate or feed/retentate fluid may collect from use of the housing. These horizontal surfaces therefore provide the potential for contamination when the housing is used in successive filtration operations.

There is therefore a need for a tangential filtration housing which reduces the risk of contamination of successive uses of the housing.

Summary of the Invention

In view of the needs of the art, the present invention provides a filtration housing for a filter cassette includes a base frame means supporting a first and second parallel upstanding plate to be movable thereon relative to each other in directions normal thereto. The filter cassette includes feed fluid passages in fluid communication with retentate fluid passages and in obstructed fluid communication through filter membranes with a number of filtrate passages. The cassette provides ports for the feed, retentate, and filtrate ports along opposed first and second edges thereof. The filtration cassette being retained between opposing first major surfaces of the parallel plates with the direction of movement thereof aligned with the axis of the membrane sheets.

The first plate defines a first channel substantially parallel to and axially aligned with first edges of the cassette, a second channel substantially parallel to and axially aligned with the second edges of the cassette, and a third channel means including a

first portion acutely oriented with respect to either of the first and second edges of the cassette and a second portion optionally substantially transversely oriented with respect to the first and second edges of the cassette or acutely oriented theretoand extending a distance therebetween.

The filtration cassette includes an axially stacked plurality of filter membrane sheets with the filtration cassette defining a stack of fluid flow chambers having multi-edged perimeters and disposed on opposite sides of and substantially coextensive with each membrane sheet. The perimeters of the membrane sheets and the chambers are sealed such that fluid flow between adjacent chambers must pass through a membrane sheet straddled thereby. Also defined by the filtration cassette are a plurality of feed passages communicating with alternating ones of the chambers adjacent first axially aligned edges thereof, a plurality of retentate passages communicating with the alternating chambers adjacent to second axially aligned edges thereof opposite to the first edges, and a plurality of filtrate passage means communicating with other ones of the chambers between the alternating ones thereof and with the filtrate passage means entering the other chambers adjacent to either the first or second aligned edges.

Included in the apparatus are a base frame and a pair of parallel plates supported by the frame and movable thereon relative to each other in directions normal thereto. The filtration cassette is retained between the parallel plates with the direction of movement thereof aligned with the axis of the membrane sheets and one of the plates defines a first channel substantially parallel to and axially aligned with the first edges, a second channel substantially parallel to and axially aligned with the second edges, and a third channel means including one portion acutely oriented to either of the first and

second edges and another portion being optionally substantially parallel or acutely oriented thereto and extending a distance therebetween.

Providing three channels in a one of a pair of end plates provides an apparatus which can be easily dismantled for cleaning or filtration cassette replacement and reduces the potential for providing horizontal surfaces on which fluid may collect and remain between uses of the housing.

According to certain features of the invention, the first channel is a feed channel communicating with the feed passages, the second channel is a retentate channel communicating with the retentate passages of the filter cassette, and the third channel means is a filtrate channel means communicating with the filtrate passage means of the filter cassette, and the transverse another channel portion is oriented acutely with respect to a surface of the one plate facing the filtration cassette and one of the first and second edges of the filter cassette. The acutely angled feed channel portions establish a specifically desirable structural arrangement providing an operator with easy access to the fittings associated with each of the channels and ensuring confidence that any fluid within the housing will drain out through the fittings.

According to other features of the invention, the filtrate channel means comprises a first filtrate channel including one portion acutely oriented to the first edges and another portion acutely oriented to thereto, and a second filtrate channel including one portion acutely oriented to the second edges and another portion acutely oriented thereto; and the filtrate passage means comprises first filtrate passage means entering the chambers adjacent to the first edges, and second filtrate passage means entering the chambers adjacent to the second edges. The use of first and second filtrate passages and channels increases the throughput of the apparatus. Moreover, forming

both portions of the filtrate channels acutely oriented with respect to the first and second edges of the filter cassette further ensures that there will be no horizontal surfaces internal to the housing on which fluid may collect after use. The present invention contemplates that the first and second filtrate channels may optionally communicate with either a single filtrate outlet port or with respective first and second filtrate outlet ports.

In one embodiment of the invention, the opposite ends of the feed channel terminate, respectively, at one side wall of the one plate and the filtration cassette facing surface thereof; opposite ends of the retentate channel terminate, respectively, at the one side wall and the facing surface thereof; and opposite ends of each filtrate channel terminate, respectively, at the one side wall and the facing surface thereof. This embodiment is useful when fluid connections to only a single side wall of a single end plate are desirable.

According to further features of the invention, filtration housing accommodates a filtration cassette having its feed passages, retentate passages, and filtrate passage means extending axially through the filtration cassette and in rectalinear alignment along the first and second edges. This arrangement provides a structurally desirable geometry for the housing.

Brief Description of the Drawings

These and other objects and features of the invention will become more apparent upon a perusal of the following description taken in conjunction with the accompanying drawings wherein:

Figure 1 is a schematic elevational view of a filtration device according to the invention.

Figure 2 is a schematic cross-sectional view taken along lines 2--2 of Figure 1.

Figure 3 is a schematic cross-sectional view taken along lines 3--3 of Figure 1.

Figure 4 is a schematic cross-sectional view taken along lines 4--4 of Figure 2.

Figure 5 is an exploded partial view of the device shown in Figures 1-4.

Figure 6 is a schematic perspective view of a modified mounting plate embodiment of the invention.

Figure 7 is a schematic perspective view of another modified mounting plate embodiment of the invention.

Figure 8 is a schematic perspective view of the reverse surface of the device of Figure 5.

Figure 9 is a schematic perspective view of a preferred embodiment of a filtration device of this invention.

Figure 10 is a schematic perspective view of the reverse surface of Figure 9.

Detailed Description of the Preferred Embodiments

Referring to Figure 1, the present invention provides a filtration housing (10) including a first and second upstanding parallel mounting end plates (12) and (13) providing major planar surfaces (16) and (17) in facing opposition. Plates (12) and (13) straddle and retain an ultra filtration cassette (14) composed of a plurality of perimeterally aligned, square-shaped components arranged in a longitudinal stacking axis (15). Supporting plates (12) and (13) are a base frame (16) that permits relative movement therebetween along the longitudinal axis (15) of the filtration cassette (14).

A pneumatic piston is affixed to base frame (16) for urging plate (13) towards and away from plate (12) for the removable fluid-tight retention of filtration cassette therebetween.

As shown in Figures 2 through 5, the filtration cassette (14) includes alternating square-shaped screen members (21a, 21b) and filtration membrane sheets (22) that are perimeterally aligned along the longitudinal axis (15). Filtration membrane sheets (22) are desirably suitable for ultrafiltration or microfiltration applications. The outer margins of screen members (21a, 21b) and membrane sheets (22) are sealed with a suitable sealant or epoxy (23) such that the screens (21) form closed chambers (24) straddling each of the membrane sheets (22). Defined by the screen members (21a, 21b) and the membrane sheets (22) are axially directed feed passages (25, 26) located adjacent to first edges (26) (see Figure 4) thereof. Similarly defined by the screen members (21a, 21b) and the membrane sheets (22) adjacent to opposite second edges (28) (Figure 4) thereof are axially directed retentate passages (29, 30). A first axially directed filtrate passage (31) (see Figure 4) extends through the stacked screen members (21a, 21b) and membrane sheets (22) adjacent to the first edges (26) thereof and between and parallel to the feed passages (25, 26). Similarly formed adjacent to the opposite edges (26) of the screens (21) and membrane sheets (22) is a second axially directed filtrate passage (32) (Figure 4) parallel to and between the retentate passages (29, 30).

Formed in the end plate (13) is an elongate feed channel (33) having a longitudinal feed passage portion (35) extending parallel to the edges (26) and communicating with an inlet port (36) in a sidewall (37). The feed passage portion (35) is in fluid communication with feed portions (38, 39) that terminate with openings in an

end wall (37) of the plate (13) facing the filtration cassette (14). Communicating with the portions (38, 39) of the feed channel (33), respectively, are the feed passages (25, 26). Also formed in the end plate (13), is a retentate channel (41) shown most clearly in Figure 3. The retentate channel (41) includes a longitudinal portion (42) extending parallel to the longitudinal portion (35) of the feed channel (33) and upwardly directed portions (43, 44) that communicate, respectively, with the retentate passages (29, 30). An outer end of the retentate channel portion (42) terminates with an outlet port (46) in the side wall (37) of the end plate (13). Additionally formed in the end plate (13) are a first filtrate channel (47) and a second filtrate channel (48) shown in Figure 4. The first filtrate channel (47) includes a longitudinal portion (51) that is parallel and adjacent to the feed (33), and a transverse portion (52) that extends between the edges (26) and (28) and communicates with the filtrate passage (31). Similarly formed is a second filtrate channel (48) having a longitudinal portion (53) that is parallel and adjacent to the retentate channel (41) and a transverse portion (54) that extends between the edges (26) and (28) and communicates with the filtrate passage (32). As shown in Figure 4, the transverse filtrate channel portions (52, 54) from acute angles with an upper surface (55) of the end plate (13). Outer ends of the longitudinal filtrate channel portions (51, 53) terminate, respectively, with outlet ports (56, 57) in the sidewall (37) of the end plate (13).

As shown in Figures 2 and 5, the portions of alternate screen members (21a) that partially define the feed passages (25) are sealed with the adhesive (23). Accordingly, no fluid communication exists between the feed passages (25) and the chambers (24) defined by the alternate screen members (21a). However, the openings in the alternating screen members (21b) that partially form the feed passages (25) are

not sealed from the chambers (24) therein so as to allow for fluid communication therebetween. Similarly, the openings partially forming the retentate passages (26) in the alternating screen members (21a) are sealed from the chambers (24) therein while the openings partially forming the retentate passages (26) in the alternating screen members (21b) are not sealed from the chambers (24) formed thereby and so as to allow fluid communication therebetween. Thus, a fluid flow path exists between the feed passages (25, 26) and adjacent one edge (26) of the filtration cassette (14) and the retentate passages (29, 30) adjacent the opposite edge (28) thereof via the chambers (24) formed by the alternating screen members (21b).

As shown most clearly in Figures 4 and 5, the chambers (24) formed by the alternating screen members (21a) communicate with the openings therein that partially define the filtrate passages (31, 32). However, the chambers (24) formed by the alternating screen member (21b) are sealed by the adhesive (23) from the openings therein that partially define the filtrate passages (31, 32). In addition, the adhesive (23) also seals the areas of the membrane sheets (22) directly surrounding the openings therein that partially define the feed passages (25, 26), the retentate passages (28, 29) and the filtrate passages (31, 32) so as to prevent fluid flow therebetween.

Operation

During use of the housing (10), the nuts (18) are loosened to permit separation of the end plates (12, 13) and insertion of a predetermined ultrafiltration filtration cassette (14) therebetween. The nuts (18) then are tightened to securely seal the filtration cassette (14) between the end plates (12) and (13). Suitable fluid handling tubing and couplings (not shown) are employed to connect the inlet port (36) to a

source of pressurized fluid to be filtered, and the outlet port (46) to a collection vessel for a retentate resulting from the filter process, and the outlet ports (56, 57) to a collection vessel for a filtrate produced by the filtration process. Pressurized fluid introduced through the inlet port (36) flow through the longitudinal and transverse portions (37, 38, 39) of the feed channel (33), the feed passages (25, 26) and into the chambers (24) formed by the alternating screen members (21b). A filtrate portion of the fluid entering the chambers (24) formed by the alternating screen members (21b) is forced through the filter membrane sheets (22) on opposite sides thereof into the adjacent chambers (24) formed by the alternating screen members (21a). That filtrate portion flows from the chambers (24) of the alternating screen members (21a) into the filtrate passages (31, 32) adjacent to, respectively, opposite edges (26, 28) of the ultrafiltration filtration cassette (14). The filtrate entering the filtrate passage (31) flows through the transverse and parallel portions (52, 51) of the filtrate channel (47) and exits through the outlet port (56). Similarly, the filtrate entering the filtrate passage (32) passes through the transverse and longitudinal portions (54, 53) of the filtrate channel (48) and exits through the outlet port (57). The retentate portion of the fluid within the chambers (24) of the alternating screen members (21b) flows between the feed passages (25, 26) to the retentate passages (28, 29) and into the transverse portions (43, 44) and the longitudinal portion (42) of the retentate channel (41) before exiting through the outlet port (46). During the filter process, the screen members (21a, 21b) may create turbulent flow within the chambers (24) that function to clean the surfaces of the membrane sheets (22) and thereby enhance the efficiency of the filtration process.

It should be noted that the apparatus depicted in Figures 1 through 5 is merely exemplary and that various dimensions have been exaggerated for purposes of

illustrative clarity. For the same reasons, the number of feed, retentate and filtrate passages (25, 26, 31, 32, 29, 30) have been limited as shown in Figures 1 through 5 while in most cases their number would be substantially increased. As shown in the modified embodiment of Figure 6, for example, an end plate (61) is provided with a feed channel (62) having five transverse portions (63), a retentate channel (64) having five transverse portions (65), and a pair of filtrate channels (66, 67) each having four transverse portions (68). The end plate (61) would be used in the same manner as described above for the end plate (13) but would accommodate an ultrafiltration or microfiltration cassette (not shown) having one feed passages, one retentate passages, and two filtrate passages. An additional modification in the end plate (61) is that ends of the feed and retentate channels (62) and (64), respectively, terminate in ports (71) and (72) in one side wall (73) of the end plate (61) while the filtrate channels (66) and (67) terminate, respectively, in outlet ports (75) and (76) in an opposite end wall (77) of the end plate (61). Use of the end plate (61) would by desirable when fluid handling equipment would be most easily positioned on opposite sides of the ultrafiltration apparatus.

Figure 7 shows another end plate embodiment (71) for use when fluid connections are desired at opposite sides of the apparatus. As in the embodiment of Figure 6, the end plate (81) is provided with a feed channel (82) having five transverse portions (83), a retentate channel (84) having five transverse portions (85), and a pair of filtrate channels (86, 87), each having four transverse (88). However, in this embodiment the transverse portions (83) and (85) of, respectively, the feed and retentate channels (82) and (84) in addition to the filtrate transverse portions (88) entered acutely from an upper surface (89) of the end plate (81) and in a direction

between opposite edges of a filtration cassette retained thereby. This embodiment further enhances the ability to separate the filtrate channels (86) and (87) from the feed and retentate channels (82) and (84) in a single end plate (81). Use of the end plate (61) would be in a manner similar to that described above.

Obviously, many modifications and variations of the present invention are possible in light of the above teachings. It is to be understood, therefore, that the invention can be practiced otherwise than as specifically described. The above mentioned embodiments are intended to illustrate the present invention and are not intended to limit the scope of protection claimed by the following claims.